Remarks

Reconsideration and withdrawal of the outstanding, newly formulated art rejections and early allowance of the above-identified application is respectfully requested.

With the above-made amendments, claims 1-4, 6-27 and 30-34 remain pending, of which independent claims 1, 24, 30 and 31 are currently amended. Claims 13-23 stand withdrawn for purposes of examination as a result of an earlier Restriction Requirement.

Each of the independent claims were amended to further highlight the characterizing aspect of applicants invention, namely, that the improved model is indicative of characteristic of the film over a wide range of wavelengths including in the UV (ultraviolet) wavelength range, the model taking into account transitions between a band and interband states in the band gap of the film. This relates to Figs. 1 and 2 of the drawings and the discussion on page 4, line 17, to page 5, line 13; page 9, line 16, to page 10, line 7; and on page 14, lines 2-5, of the Specification. This part of the description concerns the "quantum mechanical transition equation for transitions between at least one of valence and conduction bands and interband states in a band gap" (see dependent claim 6). The description leading up to equations (4) and (5), on page 11, of the Specification, which take into account the referred-to "anomalous variations" in the physical parameters (e.g., a sudden upward shift followed by a sudden downward shift) such as of the refractive index or

reflectances, discussed with regard to Fig. 2 of the drawings, is also related thereto. In other words, as can be seen from Fig. 2 of the drawings, the plot based on the simulation using the Cauchy formula is not accurate over a wide range of wavelengths, inclusive also of the UV (ultraviolet) wavelength range. This can be seen from the fact that the Cauchy formula does not account for changes resulting from the presence of interband states in the film material. To this end, the improved scheme achieved by the present inventor facilitates the calculating of one or more physical parameters (e.g., optical properties) of a film by relating the parameter(s) to the scattering caused by the interband states even for measurements with light in the UV range. It should be noted, the further limiting aspects incorporated into each of the currently pending independent claims was taken from that contained in the now canceled dependent claims 28 and 29. Discussion will now turn to the art rejections.

Claims 1-4, 6, 11, 12 and 24-34 stand rejected under 35 USC §103(a) over the combination of "Zawaideh (5,999,267) in view of Jellison et al ... further in view of Adachi ... [and] further in view of Solomon et al (5,900,633)"; and claims 7-10 stand rejected under 35 USC §103(a) over the aforesaid same combination of references "and further in view of applicants' disclosure of prior art." As will be shown below, the invention according to claims 1-4, 7-12, 24-27 and 30-34 could not have been achieved even from the combined teachings of the named references, as cited in the outstanding rejections. Therefore, these rejections, insofar as presently applicable, are

traversed and reconsideration and withdrawal of the same is respectfully requested.

The invention according to claims 1+ sets forth a method of calculating at least one physical parameter of a film wherein the improvement includes using a model for relating the physical parameter(s) to be calculated to scattering caused by interband states, the model being indicative of the characteristic of the film over a wide range of wavelengths including in the UV wavelength range, and being such that it takes into account transitions between a band and interband states in a band gap of the film. The invention according to claims 24+ and 30, which set forth an apparatus, similarly employs such a model for calculating as that set forth in independent claim 1. The invention according to claims 31+, which is presented using the Beauregard claim construction format, is also characteristic of this.

The referred to "at least one physical parameter" in the independent claims is further characterized as an optical property of the film and may be selected from the group consisting of optical dispersion, refractive index and the extinction coefficient of the film (see dependent claims 2-3, etc.). According to a featured aspect of the claimed subject matter, the model includes a quantum mechanical transition equation for transition between at least one of valence and conduction bands and interband states in a band gap (see dependent claims 6-8). Moreover, the model can be used for calculating the refractive index (n) and the extinction coefficient (k) such as set forth with

regard to dependent claim 9. In accordance with the invention, measured data of an optical property of the film such as for obtaining the fitted parameters may be obtained from a reflectometer or an elipsometer (see claim 10). The method according to claim 1 and the apparatus according to independent claim 24 feature the improved "model" to calculate the refractive index and the extinction coefficient of the film (see claims 3, 4 and 9, as well as claims 26 and 27). The present invention is especially advantageous in connection with applying the improved model to semiconductor and dielectric film material having varying levels of interband states (see dependent claims 11 and 12).

As discussed in the original Specification, the "model", according to the present invention, overcomes the limited usefulness of other empirical models including the Couchy empirical model, discussed on page 4, line 8 et seq. and on page 9, line 1, et seq. and Figs. 1 and 2 of the drawings. For example, the scattering of electrons caused by the presence of interband states such as shown in Fig. 2, with regard to the wavelength range 2000-2200Å and the wavelength range 2300-2450Å, cannot be explained using known empirical models such as the Couchy empirical model or that in view of the combined teachings of the applied references.

The improved "model", according to the present invention, relates the set forth <u>at least one physical parameter</u> such as one or more optical property <u>to scattering caused by interband states</u> in the band gap of a film, <u>the model taking into account transitions between a band and interband states in a band gap of</u>

the film, this being done by taking optical measurements over a wide wavelength range including also with regard to the ultraviolet (UV) wavelength range. In the Fig. 1 illustration, the measured transition is between the valence band and the interband state level E_D in the band gap of a film effected by the band gap energy difference between the valence band and the conduction band. Thus, there can be calculated the imaginary part $\varepsilon_2(\omega)$ as well as the real part $\varepsilon_1(\omega)$ associated with the dielectric film characteristics which are given by equations (4) and (5) (see page 11 of the Specification and claims 7 and 8). It is emphasized, the "model" which sets forth the equation according to claim 8, takes into consideration transitions between the band such as a valence and/or conduction band with that of interband states such as that associated with energy level E_D in Fig. 1, in clear contradistinction with that of the cited art as applied in the outstanding rejections. The improved model according to independent claim 1 et seq. is also applied with regard to formulating the empirical relationships for calculating the optical property such as refractive index (n) and extinction coefficient (k) of the film (see claim 9 and page 12, line 1 et seq., of the Specification). It is submitted, the invention according to claims 1+, 24+, 30 and 31+ could not have been achieved from the combined teachings of the references, as alleged in the outstanding rejections.

Zawaideh employed a technique which uses the "concept of relative shift (ratio) of power spectral density as a function of incident angle to simultaneously measure optical constants in thickness of single and multilayer

films … ." (Column 1, lines 53-59, in Zawaideh.) The technique taught by Zawaideh is described with regard to Figs. 1 and 2 thereof. Zawaideh's scheme measures reflectance (or transmittance) for normal and oblique angles of incidents over a wide spectral range using a spectrophotometer (e.g., detectors 12, 16). Regarding Fig. 2 of Zawaideh, the method employed determines optical constants such as the coefficient of refraction (n) and the extinction coefficient (k) and also determines the thickness of the film which may be a single or multilayer film (see 13 in Fig. 1).

It is stated in the outstanding rejection, that "[a]s for using a model for relating scattering caused by interband states and the model taking into account transitions between the band and interband states in the band gap of film using quantum mechanical transition equations, Zawaideh is silent." It is further stated, that [Zawaideh] "does use models from Jellision (column 4, lines 32-40)" and that "Jellison implies scattering is used in the modeling of silicon by mentioning surface roughness …and Jellison teaches that optical parameters are derived from quantum mechanical transitions between interband and band states using quantum mechanical transition equations…. ." Regarding Jellison Jr. et al's model, referred to in Zawaideh, it is, basically, a general dispersion formula for describing the optical constants refractive index (n) and extinction coefficient (k). (column 4, lines 33-39, in Zawaideh.) Jellision's model, it is submitted, does <u>not</u> relate the physical parameter(s) to scattering caused by interband states, using an optical approach over a wide range of wavelengths

including in the UV wavelength range, taking into account transitions between a band (e.g., conductance band or valence band) and interband states in the band gap region.

From Jellison Jr. et al, the imaginary part of the dieletric function ε_2 is determined by multiplying the Tauc joint density of states by the ε_2 obtained from the Lorentz oscillator model. In this regard, Jellison Jr., et al employed the Kramer-Konig integration relation (see equation (5) on page 372 in Jellison Jr., et al.) in which P represents the Couchy principal part of the interval. Although this relation is similar to the Kramer-Konig relation shown in line 13 of page 11 of the present Specification, it does not take into account the transitions between the band and an interband state in the band gap of the film, covering a band width inclusive of the UV wavelength range, as earlier discussed in these remarks and as explained in the present Specification. None of the equational relationships, it is believed, correspond to the "model" set forth in independent claims 1, 24, 30 and 31 and also according to the corresponding dependent claims thereof. For example, in the TL model (which is based on the Tauc joint density of states and the Lorentz oscillator), according to Jellison Jr., et al, the parameterization is directed to only interband transitions (see page 373, column 2, lines 7-9). However, the inventor's improved "model" <u>relates the physical parameter(s) to scattering caused by interband states, taking into account transitions between a band and interband states in a band gap of a film</u>. Therefore, the equational relationships such as

for calculating the refractive index (n) and extinction coefficient (k) of the film (see claim 9 and equations (6) and (7) on page 12 of the Specification) use values for the real part of the dielectric function $\varepsilon_1(\omega)$ and the imaginary part of the dielectric function $\varepsilon_2(\omega)$, based on the improved model, thereby yielding a different relationship from that of the applied art. In other words, Jellison Jr., et al, applicants submit, did not take into the account the "anomalous variations" referred to in the Specification and mentioned earlier in these remarks, which led the present inventors to scheme a "model" which relates the physical parameters to scattering caused by interband states covering a wide wavelength range inclusive of the UV wavelength range, taking into account the transitions between the band and interband states in the band gap of the film.

It is also submitted, Adachi did not overcome the deficiencies of the other applied references even when all the references are combinedly considered. Adachi disclosed a scheme for calculating optical constants by using the energy-band structures of materials to formulate his model of calculating the refractive index, the extinction coefficient and the normal-incidence reflectivity. Although Adachi mentions in column 2, lines 4-7, on page 3224, "indirect-band-gap transitions," there does not appear to be any teaching of modeling the parameterization to the scattering caused by interband states, the model being characteristically indicative of a film over a wide range of wave lengths including in the UV wavelength range and taking into account

transitions between a band and interband states in a band gap of the film, as called for in each of the independent claims. This appears to also be evident from the fact that the equations pertaining to the improved "model" such as set forth in claims 7-9, are also formulated differently from that of Adachi.

Solomon et al disclosed a technique for determining the thickness and composition of layers of a patterned sample associated with the manufacture of semiconductor integrated circuits. In this regard, Solomon et al employ FT-IR (Fourier transform Infrared) Spectroscopy for the computing of the infrared reflectance of samples which have multilayered and graded compositional profiles. The model employed, according to Solomon et al, follows the transfer matrix computing formalism developed by Abeles and the general guidelines given by T. Buffeteau and B. Despat. The theoretical model serves to compute the complex dielectric function of silicon as a function of frequency and doping density and is then used to calculate the reflectance spectrum for the chosen doping profile. (Column 7, line 62 et seq.; column 8, line 17 et seq. and line 33, et seq., in Solomon et al.) It is also stated, in Solomon et al, that "[t]he model is so designed that any parameter can be a fitting parameter if necessary, thus allowing the adjustment of parameters that may not be known or available, such as the carriers scattering rate (see column 8, line 64, to column 9, line 9). It is submitted, however, the improved model according to claims 1+, 24+, 30 and 31+could not have been realized from Solomon et al or, for that matter, over the combined teachings of the cited references as applied in the respective

rejections. There does not appear to be any teaching in Solomon et al which, for example, overcomes the limitations of the Couchy empirical model and as that earlier discussed above and as more clearly presented in the present Specification. The models discussed in Solomon et al, it is submitted, do not appear to show any resemblance to that of the present invention. Therefore, even if, *arguendo,* one of ordinary skill would have applied the teachings of all of the references combinedly, the invention according to claims 1+, 24+, 340 and 31+ would still not have been realizable therefrom.

Evidence based on the cited art, even when applied combinedly, must suggest or teach the claimed invention and must, also, show an incentive to combine the teachings at the time of the invention. Such incentive, however, is given only by applicant's own disclosure. In other words, hindsight reconstruction cannot be used as a means to achieve the present invention. Further, that which is within the capabilities of the skilled artisan is not necessarily synonymous with obviousness unless there is evidence to combine the teachings of the cited art and make any necessary modifications (without prior knowledge of applicants invention) that would have led to the present invention. *Ex Parte Gerlach et al, 212 USPQ 471(*USPTO Board of Appeals 1980); in re Fine, 5 USPQ 2nd, 1596 (CAFC 1988). For at least the above reasons, the invention could not have been achieved in the manner as that argued in the rejections.

Therefore, in view of the amendments presented hereinabove, together with these accompanying remarks, reconsideration and withdrawal of the outstanding rejections as well as favorable action on all of the presently pending claims, i.e., claims 1-4, 6-12, 24-27 and 30-34, and an early formal notification of allowability of the above-identified application is respectfully requested.

To the extent necessary, applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including Extension of Time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Dep. Acct. No. 01-2135 (178.39931X00), and please credit any excess fees to such deposit account.

Respectfully submitted,
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